NOVA SCOTIA
MUSEUM

CURATORIAL REPORT NUMBER 86

Invertebrate Fauna of Nova Scotia Caves

by Max Moseley

Quedius speleaeus speleaeus Horn, Staphylinidae

A FAMILY *of* 25 MUSEUMS

NOVA SCOTIA
Education and Culture

CURATORIAL REPORT NUMBER 86

Invertebrate Fauna of Nova Scotia Caves

by Max Moseley
cover illustration by Ales Smetana

Nova Scotia Museum of Natural History
Nova Scotia Museum
Nova Scotia Department of Education and Culture

CURATORIAL REPORTS

The Curatorial Reports of the Nova Scotia Museum make technical information on museum collections, programs, procedures and research accessible to interested readers.

This report contains the preliminary results of an on-going research program of the Museum. It may be cited in publications, but its manuscript status should be clearly noted.

CONTENTS

THE INVERTEBRATE FAUNA OF NOVA SCOTIA CAVES

Max Moseley, Research Associate, Nova Scotia Museum of Natural History

Nova Scotia is fortunate in having extensive karstlands. There are large areas of sulphate (gypsum) karst in mainland Nova Scotia (Hants, Colchester, Halifax, Cumberland and Antigonish Counties) and on Cape Breton Island (Inverness and Victoria Counties). There are also several smaller areas of carbonate (limestone) karst (Moseley 1996). Both types of karstland are richly endowed with features of geological, zoological and botanical importance, both on the surface and underground.

One of the unusual features of karsts is the presence of dissolution caves and the diverse biota which they contain. This is as true in Nova Scotia as elsewhere in the world: more than forty caves have so far been discovered and documented in the Province (Appendix I), and they harbour a varied fauna of insects and other invertebrates, as well as bats, porcupines, deer mice, and occasional amphibians and fishes.

The invertebrate fauna found in this ecosystem is of considerable interest. The habitat itself is unusual, and it is also essentially a natural system that has not been modified by man. In Nova Scotia the fauna includes a number of rare and otherwise notable species. It is also still in an active phase of reinvasion and recolonisation following the destruction of all former fauna by the Pleistocene glaciations, and may thus prove to be of value in zoogeography and in evolutionary biology.

HISTORICAL REVIEW

The first record of a cavernicolous invertebrate in the Province was the Cave Spider *Meta ovalis* (which at that time was considered to be the same species as the European *Meta menardii*). It was reported from " among stones in damp woods and more often in cellars, wells and drains " (Emerton 1917).

However, investigation of invertebrate cave fauna in the Province really only started in the early 1960s with a B.Sc. Honours project by Dale Calder working under the direction of Dr. Sherman Bleakney (Acadia University). Calder and Bleakney (1965, 1967) conducted an intensive investigation of Frenchman's Cave (St. Croix, Hants County) focussing on the rich terrestrial microarthropod fauna of decomposing porcupine dung. They produced a species list, constructed a schematic food web, demonstrated ecological succession during the decomposition of the dung, and compared the cave biodiversity of collembola and acari with that of surface habitats. This study was ahead of its time for this country: more than three decades later it still remains the most intensive published study of the invertebrate fauna of any single Canadian cave. Its only significant limitation is that the fauna in several major taxa (oligochaeta, isopoda, chilopoda, and symphyla) could not be identified because no specialists in these groups were available, and most of the diptera and acari could only be identified at the generic level. Aquatic invertebrates were not included.

At the time that Calder and Bleakney were working in Frenchman's Cave, only three dissolution caves were widely known in Nova Scotia: Hayes Cave (South Maitland, Hants County), Miller's Creek Cave (Mantua, Hants County) and Frenchman's. Most of the caves that have been documented subsequently were well known only to local residents or in a few cases have only been discovered since. The discovery, exploration and documentation of new caves still continues today.

The desirability of a broader, extensive rather than intensive, survey of the Provincial cave fauna has been apparent for a long time, but has had to take second place to the exploration and survey. During the 1970s the present writer did some sporadic collecting, with this purpose in mind, of invertebrates from various terrestrial and aquatic cave habitats in both mainland Nova Scotia and Cape Breton Island. A few of these records were published (Anon 1974, 1975). Further limited collecting was started again upon the writer's return to Nova Scotia from overseas in 1985. This exploratory work revealed considerable invertebrate biodiversity and showed the existence of a variety of aquatic and

terrestrial cave habitats other than those described in Frenchman's Cave.

The only other directly related research during this period was a useful study of environmental conditions in Hayes Cave done in 1978-1984 by the staff of the Nova Scotia Museum of Natural History (Scott 1979, Morris 1985).

During 1997 the present writer was able to do a broader survey of the terrestrial and aquatic invertebrates of caves in Nova Scotia.

The purpose of this Curatorial Report is to make available the results of this survey, together with all published and, where available, unpublished, previous records, in a comprehensive form. It includes unpublished collection data, together with a few entirely new records, from Calder's work in Frenchman's Cave, all of my own pre-1997 records, and a number of spider records based on material in the Natural History Collection of the Nova Scotia Museum. The identification of species belonging to several taxonomic groups is not complete, but, as this sometimes takes years, it is felt appropriate to issue a report now. In addition to its biospeleological interest, it is considered important that such information be made quickly available for use in environmental impact assessments of sites in karst areas of Nova Scotia.

METHODS

A variety of collecting methods are used in order to obtain a representative suite of species from a cave. Visual searching is the standard method, and whilst slow and tedious is usually the most rewarding in terms of total number of species. Many cavernicoles occur in very small numbers and are likely to be missed unless carefully searched for on site. Bulk sampling and laboratory extraction techniques such as Tullgren Funnel extraction and flotation methods are also very useful in appropriate cases e.g. in sampling porcupine dung and plant flood debris. It is important to note however that some food sources such as flood debris may be in short supply in a cave and their removal can be ecologically destructive. The collecting and removal of such materials must be sparing and scientifically justified. Pitfall traps are useful for taking mobile species, but must be used with considerable caution because of the danger of overcollecting rare species. A variety of baits are sometimes used, but with even greater caution for the same reason and also because the presence of a bait will often upset the ecological balance in the cave. Mass collecting methods such as pitfalls, light traps, and baits should *never* be used in a cave except under the direct supervision of an experienced cave biologist.

Aquatic fauna is sampled by means of small hand nets (such as those sold by aquarium suppliers), small plastic kitchen sieves, simple plankton nets and similar rugged easily obtained devices.

In most cases, specimens are collected straight into 70% alcohol (ethanol or isopropyl). Some insects are best killed and dry pinned, and some invertebrate groups (e.g. planarians) require special methods of fixation and preservation. The latter are best collected live, and killed and fixed back at the laboratory. Refer to standard texts on museum techniques for appropriate methods.

One of the biggest problems in cave faunal surveys is distinguishing accidental trogloxenes, regular trogloxenes, troglophiles and troglobites (see below). Records of the same species from several different caves and/or over a long period of time are particularly valuable for this purpose.

Another problem is taxonomy. As emphasised by Howarth (1988) "it cannot be stressed too strongly that a study of this type is only as good as the systematics research upon which it is based." Many cavernicoles belong to specialist groups such as nematoda, collembola, acari and certain groups of diptera such as sciarids. These can only be reliably identified by a taxonomist who is a specialist in that group. In these cases it is a waste of effort, and bad science, to publish species lists based on identifications by non-specialists. In the present survey, all efforts have been made to have identifications in specialist groups confirmed by recognised experts. Where this has not yet been possible, taxa are usually reported only to genus, family or higher group. Where tentative identifications have been assigned they are always clearly indicated as such.

THE ECOLOGICAL CLASSIFICATION OF CAVERNICOLES

The most commonly used classification is the Schiner-Racovitza system, named after its originator J. R.Schiner and modifier E. Racovitza . According to this system, animals found in caves are classified according to their degree of ecological dependence on the cave environment, as follows:-

TROGLOBITES - Obligate cavernicoles. Species which can survive only in caves.

TROGLOPHILES - Facultative cavernicoles. Species which survive and are able to complete their life-cycle in caves, but also survive and complete their life-cycle in other habitats.

TROGLOXENES - Species found in caves which cannot complete their life-cycles there:-

- Regular Trogloxenes: Species which habitually frequent caves and thus, whilst not completing their life-cycle there, form a part of the cave community.
- Accidental Trogloxenes: Surface (epigean) species introduced accidentally e.g. by floods.

XENOPHILES - "False cave dwellers"

- Parasites: Endo- or exoparasites of cavernicoles.
- Guanophiles: Species which, when found in caves, are restricted to dung or guano. Some guanophiles complete their life-cycle underground.

This classification has been critisized on a number of valid grounds, but is now widely used and understood, and provided that it is not interpreted pedantically, it is a useful and convenient shorthand pointing to the ecological status of species recorded from caves. For these reasons it is used in this report.

The general term "cavernicole" is used herein to mean a troglobite, troglophile or regular trogloxene.

THE CAVE ENVIRONMENT

Because caves are a strongly zonal environment (Howarth 1988) the simplest classification is based on the zonation from the entrance in:-

THRESHOLD - The zone from the cave portal to the furthest limit of vascular plants. It typically displays a plant zonation with ferns at the entrance, then mosses only, and sometimes green algae furthest in.

DEEP THRESHOLD - Dim light zone, sometimes called the "twilight zone". From the inner limit of vascular plants to the beginning of absolute darkness.

DARK ZONE - Those parts of the cave which are always in total darkness.

From a biological perspective, the dark zone can be subdivided into three distinct subzones (Howarth 1988), as follows:-

TRANSITION ZONE - Area of the cave that is in total darkness, but where short-term climatic events on the surface still have conspicuous effects. It is subject to temperature and barometric changes, and may be exposed to air currents.

DEEP CAVE - Area of the cave where the climate remains stable for extended periods. It has a relatively stable temperature, and typically constant near 100% relative humidity. However air exchange with the surface keeps the air fresh.

STAGNANT AIR ZONE Areas where air exchange is restricted. Relative humidity is 100%. Gasses from organic decomposition, especially carbon dioxide, build up. Radon from decaying heavy isotopes in the rock also often accumulates here.

The presence of a stream in a cave obviously affects the environment significantly.

It is doubtful that any of the small caves found in Nova Scotia contain a true stagnant air zone, although the presence of radon gas accumulations (Morris 1985) suggest that areas in Hayes Cave approximate it. There are a few sites that can be considered deep cave: the draft-free areas of Hayes Cave remote from either entrance, and the inner part of Frenchman's Cave beyond a restricted crawlway are two. The chamber of Miller's Creek Cave was a good example before this important site was quarried away in the early 1980s. Most other dark zone sites can only be considered transition zone, either because they are close to the entrance or because of the presence of a stream sinking from the surface.

The air temperature in the deepest parts of Hayes Cave varies about 2°C annually, between approximately 5.5°C in mid-winter to 7.5°C in late summer.

The annual temperature range in Frenchman's Cave just *before* the crawlway is approximately 2°C-7.5°C. This range may be considered fairly representative of a typical local cave.

There are instances where the aspect and physical shape of a cave produces atypical conditions. In the so-called "Ice Caves" the particular conditions result in the survival of ice well into the summer and unusually low temperatures. Woodville Ice Cave (Woodville, Hants County) has a north facing entrance at the head of a deep blind valley, and consists of a large chamber which acts as a cold trap. Due to these physical conditions, ice which accumulates during the winter can survive at the back of the chamber until early August: the maximum temperature measured at this point in the summer of 1997 was only 3.9°C. It is interesting to note that if the mean annual temperature at Woodville were perhaps as little as 1°C lower this cave might be a true ice cave containing permanent ice.

The temperature of the waters in most caves in the Province approximates the cave air temperature. However some underground springs originate from deep phreatic waters and have a temperature close to that of the annual mean. Examples are the small spring in Minasville Ice Cave (4.3°C in September 1995) and the Frenchman's II cave stream (5°C in July 1997).

Due to its high solubility (2.438 gms per litre distilled water at 10°C) gypsum cave waters are usually saturated with calcium sulphate. The conductivity of water samples from ponds in Hayes Cave was 2210-2230 µS/cm (Scott 1979). I have taken water samples that were so high in sulphate that it precipitated out as microscopic crystals of selenite upon chilling.

THE ORIGIN OF THE NOVA SCOTIA CAVE FAUNA

The whole of Maritime Canada was subjected to widespread multiple glaciations during the Pleistocene. Undoubtedly all existing cavernicolous fauna was wiped out, and thus the whole of our present day cave fauna is a result of post-Pleistocene reinvasion and colonisation. This process still continues today, as evidenced by the number of introduced European species in the fauna lists.

The chronology and routes by which the Nova Scotia freshwater and terrestrial invertebrate faunas recolonised the Province following the Pleistocene remain a matter of investigation and debate, and therefore little can yet be said about the history of the cave fauna. A comparison of the list in this Curatorial Report with that of Ontario caves by Peck (1988) shows that our cave fauna is relatively impoverished in terms of biodiversity: this becomes particularly apparent when it is noted how much of it is associated with porcupine dung, a habitat that was not even mentioned by Peck. How much of this restricted biodiversity is due to the zoogeographical barrier introduced by the Tantramar Marshes is merely conjectural for now: a comparative comprehensive survey of the cave fauna of New Brunswick might help to elucidate this question.

As pointed out by Calder & Bleakney (1965) the porcupine was a relatively late postglacial arrival in Nova Scotia and they concluded that because much of the cave fauna is associated with porcupine dung it must be even more recent. However, few if any of the species concerned are likely to be obligate guanophiles that are totally specialist on porcupine dung so this argument is untenable.

CAVE COMMUNITIES IN NOVA SCOTIA: TERRESTRIAL

PARIETAL ASSOCIATION

Caves contain a distinct faunal assemblage that lives or rests on the rock walls and ceiling, and which is referred to as the " parietal association". This fauna tends to be richest both in number of species and in number of individuals in the deep threshold, but it extends into the dark zone. In Nova Scotia caves parietal species are found throughout.

The parietal association has been well described in Europe, but much less so in North America. However, there is no doubt that it is taxonomically diverse here: Peck (1988) found that the majority of species in a survey of Ontario cave fauna were members of this complex.

The species composition of the parietal fauna changes seasonally. In Nova Scotia it includes a number of species that are overwintering in caves (e.g. *Culex* spp., *Leiobunum elegans*), one species that shelters in caves and forages outside (*Ceuthophilus brevipes*), and a spider that specialises in predating other parietal fauna (*Meta ovalis*). The majority of species are diptera (see list below): without many more field records it is not possible to determine the seasonality of most of these, but several are probably primarily overwinterers.

A *Leiobunum* that had been caught in a *Meta ovalis* web was observed in Peddlar's Tunnel. Evidence of the predation of diptera by this spider is rare, and it is likely that it specialises on larger invertebrates such as harvestmen, millipedes and woodlice.

The following list of the parietal fauna of Provincial caves is based only on the extant collection records. Further work will undoubtedly add considerably to the number of species, and much additional collecting will be needed in order to establish the seasonality of most parietal taxa:-

ISOPODA	Oniscus asellus	th.-d.z	
DIPLOPODA	Blaniulus guttulatus	th.-d.th	
ORTHOPTERA	Ceuthophilus brevipes	th.-d.th.	year-round
LEPIDOPTERA	Scoliopteryx libatrix	d.th.-d.z.	
DIPTERA	Boletina sp(p). indet.		
	Bolitophilia sp(p). indet.		
	Exechia sp(p). indet.	th.-d.z.	
	Exechiopsis sp(p). indet.	th.-d.z.	
	Tamania tamanii	th.-d.th.	
	Culex sp(p). indet	th.-d.z.	overwinterer (females)
	Anopheles sp. indet.		
	?Chaoborus sp. indet.	th.-d.th.	
	Psychoda sp(p). indet.	th.-d.z.	
	Limonia cinctipes	th.	
	Trichocera maculipennis	th.-d.z.	year-round
	Scoliocentra fraterna		
	Heleomyza serrata	d.th.-d.z.	
	H. ?brachypterna		
	Amoebaleria ?defessa	d.th.-d.z	
	?Tephrochlamys sp.	d.z.	
	Leptocera sp(p).indet.	th.-d.z.	
ARANEA	Meta ovalis	th.-d.z.	year-round
OPILIONES	Leiobunum elegans	th.-d.th.	overwinterer
GASTEROPODA	Arion fasciatus	th.	
	Zonitoides arboreus	th.-d.z.	

Significant sites. Parietal species are present in all caves and mines in Nova Scotia. The greatest biodiversity observed in the course of the present survey is in Frenchman's II (St. Croix, Hants County) and Weir Brook Cave (St. Croix, Hants County). Both are damp (stream) caves with constricted entrances, and support unusually diverse faunas, particularly diptera but also isopoda, diplopoda and mollusca. Peddlar's Tunnel (Minasville, Hants County) also has a diverse parietal fauna (Culicidae, Mycetophilidae, Heleomyzidae, mollusca, *Meta*, etc.) and in addition is very important as the only known Provincial site with overwintering aggregations of *Leiobunum elegans* (Moseley and Hebda, in prep.) and the only known surviving Provincial cave colony of *Ceuthophilus brevipes*. Peddlar's Tunnel is an important potential research site for work on any of these species because it is accessible, and being an artificial adit with relatively smooth walls and ceiling, individuals can be seen and counted. This is not possible in caves. Cheverie Cave (Cheverie, Hants County) should also noted here because of its easy access next to a paved road, and the presence of a rich parietal dipteran fauna (Culicidae, Mycetophilidae, Heleomyzidae).

PORCUPINE DUNG

Most caves in Nova Scotia are used as shelter by porcupines (*Erethizon dorsatum*). These animals leave their faeces in the cave. In some cases these may accumulate as deposits tens of centimetres in depth and covering several square meters of cave floor. Similar, but smaller, accumulations have been observed in New Brunswick caves.

Decomposing porcupine dung is a rich high-energy food source forming the basis of a complex food web that was described by Calder and Bleakney (1965). Because most of the major cave areas in North America are south of the range of the porcupine, this unusual habitat must be considered a notable and significant cave ecological feature in Nova Scotia.

Fresh porcupine scat consists of ovoid dark greenish-brown pellets with a mucoid surface.. As they decompose the mucoid surface material disappears rapidly but the pellets retain their shape and physical integrity for a considerable time.. They turn brown and the fibrous nature of their constituents

becomes visible. In the later stages of decomposition they break down physically into their constituent fibres forming a material that looks somewhat like well-weathered sawdust. The moisture content at all stages is dependent upon the physical location: caves vary in humidity and in the presence or absence of free water as, for example, seepage or roof drips. In Frenchman's Cave, Calder and Bleakney (1995) found a gradual decrease in acidity according to the stage of decomposition: from pH5.1 in "poorly decomposed" material, pH5.3 in "well-decomposed" through to pH6.3 in "thoroughly decomposed faeces". I have however found that the variation in pH between sites is as great or greater than the variation measured in Frenchman's Cave. The following measurments are based on a total of twenty-six samples from several sites:-

"poorly decomposed"	mean = pH6.3	range = 5.1-7.3
"moderately decomposed"	mean = pH5.9	range = 5.3-6.9
"thoroughly decomposed"	mean = pH6.5	range = 5.9-6.6

Note that the range is greatest in the case of "poorly decomposed" scat. It is probably dependent upon the amount of water. Cave water in gypsum caves is usually alkaline (pH7.1-7.6) so dung pellets subjected to drip or seepage water may be expected to have their acidity neutralised fairly rapidly. For example the extreme pH7.3 measurement above was a sample of scattered pellets lying on the floor in a very wet area.

The first stage in the arthropod colonisation of fresh dung is probably egg laying by various diptera. Behaviour that suggests this was observed in October 1997 when several very fresh pellets of porcupine scat lying on an otherwise clean rock surface in Frenchman's II were seen surrounded by a small swarm of flies. There were at least three species - a sciarid (possibly *Scatopsciara*), a sphaerocerid (*Leptocera* sp.), and a chaoborid (possibly *Chaoborus*). Dipteran larvae are frequently abundant in porcupine dung in caves..

Thereafter the biomass and species composition of the invertebrate community of decomposing dung is very variable and depends on a variety of factors including moisture content, stage of decomposition, the cave zone, temperature profile of the site, pH and season. Based on observational evidence, moisture content is the most important single factor. As might be expected biomass and biodiversity decrease in dry material. The presence and abundance of enchytraeid worms in particular is sensitive to the moisture content. With respect to stage of decomposition, Calder and Bleakney (1965) found Acari to be dominant in "poorly decomposed" samples, whilst collembola became dominant later. I have seen evidence of a similar sequence.

The larger predators are represented by a Staphylinid beetle (*Quedius spelaeus*) which has been collected in several caves. The adults are usually found on or near porcupine dung. The larvae occur in moderately decomposed dung accumulations. Other predators are possibly Erigonid spiders, two species of which have been collected: additional records however are necessary to confirm these as cavernicoles rather than merely rare accidentals.

The invertebrates recorded from this habitat are:-

OLIGOCHAETA	Dendrodrilus rubidus	rare
	Enchytraeid spp. indet.	abundant
DIPLOPODA	Proteroiulus fuscus	rare
	Ophyiulus pilosus	occasional
	Polydesmus angustus	occasional
COLLEMBOLA	Willemia scandinavia	rare
	Onychiurus pseudarmatus	common or abundant
	O. armatus species complex	common or abundant
	Onychiurus spp. indet.	abundant
	Tullbergia iowensis	(?) occasional
	T. roseki	occasional
	Folsomia fimitaria	common or abundant
	F. stella	common or abundant
	F. candida	occasional

	Isotoma sp. nova ?	occasional
	Megalothorax minimus	rare
COLEOPTERA	Quedius spelaeus (adult)	common
	" " (larva)	common
	?Acrotrichia sp.	occasional or common
LEPIDOPTERA	Amydria effrentella	(may be an Accidental)
DIPTERA	sciarid sp(p) indet. (larvae)	
	Smittia sp(p) indet. (larvae)	
	Trichocera maculipennis (larva)	abundant
	dipterid larvae spp. indet	
ACARI	Acarus immobilis	(an Accidental)
	Epicriopsis sp. indet.	
	Alliphis sp(p) indet.	
	Geholapsis sp(p) indet.	
	Zerconopsis sp(p) indet.	
	Bryobia praetiosa	(an Accidental)
	Pygmephorus sp(p) indet.	
	Arctoseius sp(p) indet.	
	Parasitus sp. nr. loricatus	
	Vulgarogasmus nr. remberti	
	Parasitus sp(p) indet.	
	Eugamasus sp(p) indet.	
	Bakerdania sp. indet.	
	Rhagidia sp. indet.	
	Vegaia sp. indet.	
	Acari spp. indet.	
ARANEA	Sisicottus montanus	(may be an Accidental)
	Grammonota sp. indet.	(may be an Accidental)

Significant sites. Frenchman's II contains the most significant porcupine dung fauna encountered to date. There are large deposits both in the deep threshold, and well into the dark zone. Both are in apparently ideal humidity conditions. They support a rich diverse fauna including most of the species listed for this habitat type, plus species which have not been found in caves elsewhere in the Province (?*Acrotrichia, Polydesmus angustus*). The deposits that were studied by Calder and Bleakney in Frenchman's Cave have largely decomposed and seem to have dried over the last three decades, but remain significant for comparative purposes with the earlier findings.

BAT GUANO

Scattered bat droppings are found in caves which are used as roosts. They never form significant accumulations, but densities of up to 250 per m2 have been reported (Scott and Grantham 1985). In Hayes Cave, acari are almost always present on or close to these droppings (Scott and Grantham 1985).

Bat droppings have been observed in Hayes Cave (South Maitland, Hants County) and Minasville Ice Cave (Minasville, Hants County).

POOL SURFACE ASSOCIATION

Static pool surfaces in caves represent a special habitat type that supports a community of microarthropods referred to as the "pool surface association". The pool surface association in North America and Europe is dominated by collembola and mites. Symphyla are taken occasionally. These animals are believed to primarily depend upon bacteria on the surface film.

Illustrating the importance of this habitat in caves is the fact that troglobitic collembola from all Families display convergent evolution of the structure of their claws which are morphologically adapted

(long and slender) to enable the animal to move around on the surface film.

The collembolan species taken from this habitat in Nova Scotia are:-

Onychiurus spp. indet.
Folsomia candida
Isotoma sp. nova?
Heteromurus nitidus
Pseudosinella alba
Arrahopalites hirtus

In addition a number of unidentified acari have been collected. A single specimen of *Liposcelis* (Psocoptera) taken on a pool in Cheverie Cave is presumed to be an Accidental.

Significant sites. This habitat at any one site rarely supports more than two or three species, so there are no fully representative caves. The above collembolan species were collected from Haye's Cave, Frenchman's II, and Cheverie Cave. All these sites usually contain standing water. The significance of the habitat in caves has been emphasized above.

FLOOD DEBRIS

Where a cave contains an active stream that enters from the surface, flooding resulting from the Spring snowmelt carries in plant debris and organic sediment. This can be an important food supply in a cave, and it constitutes a special habitat because it is seasonally pulsed. Research in the United States has shown marked seasonality in the breeding cycle of many cave animals, timed to take advantage of this annual input.

The associated invertebrate community may also be rich in accidentals carried in with the plant material and which in some cases can survive for a considerable time. It can thus be extremely difficult to distinguish accidentals collected from flood debris from cavernicoles, and I have made no attempt to do so. The following list gives those species that have been collected in this habitat: those marked " * " are records of species that, in flood debris, have so far only been collected from caves in New Brunswick:-

OLIGOCHAETA	Lumbricid sp(p) indet.
	Enchytraeid sp(p) indet.
COLLEMBOLA	*Hypogastrura pseudarmata
	*Neanura muscorum
	Onychiurus spp. indet.
	Isotoma sp. nova?
	Isotoma caeruleatra
	Heteromurus nitidus
	*Pseudosinella ?collina
	Arrhopalites sp. nova?
	*Ptenothrix marmorata
COLEOPTERA	*Quedius mesomelinus
DIPTERA	?Chaoborus sp. indet.
ACARI	Parasitus sp. indet.
	Eugamasus sp. indet.
	Rhagidia wegerensis
	*Vegaia kocki
	*Linopodes motatorius
	Acari spp. indet.
MOLLUSCA	*Discus catskilliensis

Significant sites. Cave-of-the-Bats. This readily accessible stream sink cave probably represents the best example of this type of habitat in the Province. Due to a constriction at the end of the cave, spates during the Spring snowmelt backup and flood much of the cave, depositing sediment and plant debris which decompose throughout the year. Weir Brook Cave also contains small amounts of plant debris deposited by the stream, though it is not subject to intense flooding.

OTHER PLANT DEBRIS AND TIMBER

I distinguish this habitat from the former because in this case the input into the cave is not as strictly seasonal. Leaf mould and other plant material often accumulates in cave entrances, or is brought in via the channels at the bottom of sinkholes. Abandoned mines usually contain timbers that decompose over a period of many decades and often support a varied invertebrate community.

Invertebrates recorded from this habitat:-

OLIGOCHAETA	Dendrodrilus rubidus
	Aporrectodea tuberculata
	Eisenia rosea
	Enchytraeid sp(p) indet.
COLLEMBOLA	Willemia scandinavica
	Onychiurus pseudarmatus
	Onychiurus spp. indet.
	Folsomia stella
DIPTERA	Trichocera maculipennis
	Diptera larvae spp. indet.
ACARI	Parasitus sp. indet.
	Rhagidia wegerensis
	Cocceupodes sp. indet.
	Glycyphagus domesticus
	Acari spp. indet.

Significant sites. Woodville Ice Cave. This cave contains extensive accumulations of leaves and other plant debris in the threshold. The rare collembolan *Willemia scandinavica* was collected here. There are no really good known dark zone examples of this habitat in Nova Scotia caves: but many abandoned hardrock mines contain timbering that will repay examination. Hayes Cave has areas of plant debris and timber fragments.

STREAM MUDBANK COMMUNITIES

Most gypsum cave sediments consist of a characteristic fine chocolate-brown mud (a breakdown product of the gypsum). Sometimes stream banks composed of this material support a community of small oligochaete worms whose presence is indicated by casts.

Significant sites. Weir Brook Cave contains a small stream with mud banks on which casts are visible.

"CLEAN" GRAVEL AND PEBBLE FLOORS

I define this habitat as areas of clean, mud-free, damp sand, gravel and pebbles usually adjacent to an underground stream. It is a rare habitat in gypsum caves, because of the almost ubiquitous presence of mud, but is one of the most significant cave habitats in the Province due to the nature of its

faunal assemblage. In the best example found to date, this consists almost entirely of troglophiles, so is a "true" cave community. The site is characterised by a restricted food supply, moderated seasonal temperature variations and high humidity (both due to the constricted nature of the cave entrance and the presence of a cold spring inside the cave).

A list of the fauna collected from this habitat follows. Two of them, *Heteromurus nitidus* and *Arrahopalites hirtus*, appear to be "indicator" species confined (at least in local caves) to this habitat. Both are recognised troglophiles:-

DIPLOPODA	Cylindroiulus latestriatus
SYMPHYLA	Symphylella sp. indet.
COLLEMBOLA	Isotoma sp. nova?
	Heteromurus nitidus
	Arrahopalites sp. nova?
	Arrahopalites hirtus
ACARI	Acari spp. indet.

Significant sites. Frenchman's II. Contains the best example of this type of habitat so far found in the Province. This site is notable for populations of the two "indicator" species noted above. McLellan Brook Cave may also be noted.

CAVE COMMUNITIES IN NOVA SCOTIA: AQUATIC

Most caves in Nova Scotia contain water. Aquatic habitats comprise standing water, ranging from small pools on mud to large lakes; running water, ranging from tiny seeps and rivulets to large streams, and interstitial water. Cave streams may originate from the surface, or from an underground spring.

In most gypsum caves the aquatic sediment is the same fine chocolate-brown mud already mentioned above, with gypsum fragments and rocks.

Such habitats support a surprisingly diverse fauna of copepods, ostracods and microdrile oligochaetes. Planarian worms and the aquatic larvae of various diptera may also be present. Dragonfly nymphs are found frequently enough to be considered regular trogloxenes but, though individuals may stray further in, they are essentially part of the threshold fauna. The water-beetle *Agabus larsoni* was collected from a dark zone cave pool but this species is normally found in *Sphagnum* pools and it is almost certainly merely an accidental.

The autochonthus food inputs that have been observed in such habitats are (a) bat droppings (Scott & Grantham 1985), (b) porcupine dung, and (c) dead insects. Bat droppings never form into accumulations, but may be significant where other food inputs are limited. Scott & Grantham (1985) observed cyclopoid copepods apparently associated with droppings in ponds in Hayes Cave. Porcupine dung can consist of scattered droppings, or, sometimes considerable accumulations. Associated fauna includes planarians, microdriles, copepods and dipteran larvae. Dead insects (diptera and occasional coleoptera) at times accumulate in large amounts on and in cave pools. On one pool in Frenchman's II (October) I found *Trichocera maculipennis, Leptocera,* an unidentified sciarid and even *Quedius spelaeus*: all these originate within the cave community. Dead insects are undoubtedly one of the most important food inputs into this cave habitat. They support both the aquatic fauna and the pool surface association.

Allochonthus food inputs: surface streams carry in plant debris and other material. This input tends to be seasonal, with the most material being brought in by spates during the Spring snowmelt. The invertebrate fauna found in cave waters containing such material is certainly more diverse than where this food supply is not available, but it is difficult to distinguish accidentals carried in along with the plant debris from cavernicoles. Examples of such probable accidentals in the following list are the Cladocera and the water-beetle *Agabus semivittatus.*

Underground springs with cold, sediment-free water are rare but constitute a very distinct habitat. The pebble-floored streams are the only cave habitat supporting populations of mayfly larvae of the genus *Sweltza.*

Gypsum is very soluble and so water in gypsum cave ponds and springs is normally saturated. Such waters are slightly alkaline (mean pH = 7.4. Recorded range 7.1-7.6). Where significant amounts of organic material (porcupine dung, plant debris) is present, the water is slightly acidic:-

Standing pool with plant flood debris (Cave-of-the-Bats)	pH6.5
Small rivulet with porcupine dung (Woodville Ice Cave)	pH5.8
Cold spring with vegetable debris (Frenchman's II)	pH6.6

The pH of limestone cave waters is typically around 7.3.

The aquatic invertebrates collected from caves in Nova Scotia are:--

TURBELLARIA	Planarian spp. indet.	pools, streams
OLIGOCHAETA	Enchytraeid spp. indet.	pools, streams, porcupine dung
CLADOCERA	Cladoceran spp. indet.	pools
OSTRACODA	Pseudicandona albicans	pools, streams
	Cyprina sp. indet.	streams
	Cavernocypris sp. nova?	streams
	Cypridopsis sp. indet.	streams
	Fabaeformiscandona wegelini	pools
COPEPODA	Acanthocyclops robustus	pools, streams
	Acanthocyclops brevispinosus	pools, streams
	Acanthocyclops venustoides	pools
	Eucyclops agilis	pools
	Diacyclops crassicaudis	streams
	Paracyclops poppei	pools
	Macrocyclops albidus	stream
ODONATA	Aeshna umbrosa (nymphs)	pools
	Cordulegaster maculatus (nymphs)	stream (?)
	Macromia illinoiensis (nymphs)	pools (?)
PLECOPTERA	?Sweltza sp. indet. (nymphs)	streams
	Plecopteran sp(p) indet. (nymphs)	streams
COLEOPTERA	Agabus semivittatus	streams
	Agabus larsoni	pools
	?Dytiscus sp. indet	stream
DIPTERA	Dipteran spp. indet.	pools, streams

Significant sites. Hayes Cave: ponds (not subject to flooding), bat droppings. Cave-of-the-Bats: excellent example of a typical mud-floored cave stream (sink) subject to Spring spates. Weir Brook Cave: only known site for *Cavernocypris*. Frenchman's II: the best , known, example of a cold spring-fed cave stream with mayfly larvae. A number of cave sites contain standing pools and porcupine droppings: Cheverie Cave is an example. Woodville Ice Cave contains a small flowing rivulet with porcupine droppings that support populations of microdriles, copepods and various dipteran larvae. Peddlar's Tunnel is the site for the rare copepod *Acanthocyclops venustoides.*

THE LIST OF SPECIES

The following records of cave fauna are as comprehensive as I can make them. I have included all previously published records, unpublished records and collection data from Calder and Bleakney's work at Frenchman's Cave, my own unpublished collection records and the results from the 1997 fieldwork. Species indentifications in some taxonomic groups are not yet available. Records of invertebrates (many unpublished) from New Brunswick caves and mines are also given.

KEY TO ABBREVIATIONS

th. = threshold; d.th. = deep threshold; d.z. = dark zone.

CB = Cave of the Bats; CC = Cheverie Cave; FC = Frenchman's Cave; F2 = Frenchman's II; FH2 = Fairy Hole II; GM = Glebe Mine; GP = Glebe Pot; GR = Greenhead Cave; HC = Hayes Cave; HO = Howes Cave; HB = Harbels Cave; KC = Kitt's Cave; MB = McLellans Brook Cave; MC = Millers Creek Cave; MIC = Minasville Ice Cave; PT = Peddlar's Tunnel, TH = The Honeycombs; WB = Weir Brook Cave; WIC = Woodville Ice Cave.

Class TURBELLARIA

Order TRICLADIDA

Cavernicolous triclad planarians have a worldwide distribution and there are a number of troglobitic and many troglophilic species. Cave populations of the latter often show morphological differences from surface populations and can be very difficult to identify. Most cavernicolous triclads belong to the Families Dendrocoelidae, Kenkidae and Planaridae.

Family Planaridae

Planarid spp. indet.

White planarian flatworms of at least two species are present in pools in caves and mines in Nova Scotia . There are also records from New Brunswick: GP, GM (McAlpine, pers comm.); KC (sight record).

Troglophiles (?).

Class OLIGOCHAETA

Order TERRICOLAE

Earthworms are often encountered in caves and mines where they are usually associated with organic material such as rotting timber and plant flood debris. They are ocassionally found in decomposing porcupine dung, but this is close to unpalatable for them so is a marginal habitat (McAlpine & Reynolds 1977).

Family Lumbricidae

DENDRODRILUS RUBIDUS (Savigney)

FC, one, d.th. in porcupine dung (Oct) (Calder, pers. comm.).

Trogloxene (?). An introduced European species. It appears to be the most frequent cave earthworm in the United States (Gates 1959) and in Canada (McAlpine & Reynolds 1977). A

litter species, in caves and mines it is often found in decomposing wood such as old mine timbers, sometimes in other organic material.

NEW BRUNSWICK. HO, three, d.z. under logs (Oct): GP, two, d.z. in detritus (Oct): GM, two, d.z. in mine timber (Aug) (McAlpine & Reynolds 1977): KC, one, d.z. in wet wood (beaver dam) (Oct).

APORRECTODEA TUBERCULATA (Eisen)

HC, one juvenile, probably this species, d.z. crawling on damp rock (Jul).

Trogloxene (?). An introduced European species. This is the dominant earthworm in Canada (McAlpine & Reynolds, 1977).

NEW BRUNSWICK. HO, one juvenile, d.z. in detritus on wall (Mar) (Anon 1976): HO, one, d.z. in small pocket of detritus (Mar): HB, one, th. on wall (Oct); one, d.z. under rock in mud (Oct): GP two, th. under rotten log (Sep) (McAlpine & Reynolds, 1977).

EISENIA ROSEA (Savigney)

No Nova Scotia cave records.

Accidental (?). An introduced European species.

NEW BRUNSWICK. HO, one, d.z. under log (Oct) (McAlpine & Reynolds 1977).

LUMBRICUS TERRESTRIS Linnaeus

No Nova Scotia cave records.

Trogloxene (?). An introduced European species, not uncommon in Nova Scotia and may be present in caves here.

NEW BRUNSWICK. GM, one, d.z. under timber (Aug): GP, one, d.z. under rock in mud (Sep) (McAlpine & Reynolds, 1977).

Order LIMNICOLAE

Microdrile oligochaetes are often abundant in cave habitats. Enchytraeids and naiidids have been found in caves in Nova Scotia, and it it probable that tubificids are also present here. Collections from our caves are being examined by a specialist taxonomist.

Family Enchytraeidae

Enchytraeid spp. indet.

A number of unidentified enchytraeids have been found in caves and mines both in Nova Scotia and in New Brunswick. They are abundant in decomposing porcupine dung, and are also found in other oganic material as well as in aquatic habitats.

Family Naiidae

Naiidid sp(p) indet.

One or more naiidids are present in aquatic cave habitats in Nova Scotia.

Class **BRANCHIOPODA**

Order DIPLOSTRACA
Sub-Order CLADOCERA

Cladocera are not common in caves. The two species recorded below are probabaly accidentals introduced by flooding.

Cladoceran sp. indet. (Species A)
CB, several, d.z. in pool with plant flood debris (Jun).
Accidental Trogloxene.

Cladoceran sp. indet. (Species B)
CB, one, d.z. in pool with plant flood debris (Jun).
Accidental Troglxene.

Class **OSTRACODA**

Ostracods are an important component of the groundwater fauna in many parts of the world, and include many exclusively subterranean species. They are often found in cave waters. Together with cyclopoid copepods and microdrile oligochaetes they are the dominant invertebrates of cave waters in Nova Scotia, and certainly include troglophilic species.

Order PODOCOPIDA

Family **Candonidae**

PSEUDICANDONA ALBICANS
WB, several, d.th. in stream (Jul): CC, one, d.z. in pools on floor (Oct).
Troglophile. May be the most common ostracod in Nova Scotia caves.

FABAEFORMISCANDON WEGELINI
CC, one, d.z. in pool on floor (Oct).
Troglophile. An epigean species which also often occurs in near-surface cave habitats elsewhere.

Family **Cyprididae**

CYPRIA sp. indet.
WB, several,, d.th. in stream (Jul).
Status unknown.

CAVERNOCYPRIS sp. nova?
WB,, d.th. in stream (Jul).
Troglophile (?). Definately not *Cavernocypris subterranea*, and is probably undescribed. Further collections of ostracods have been made from this site and are being examined by a specialist taxonomist.

Family **Cypridopsidae**

CYPRIDOPSIS sp. indet.
WB, several, d.th. in stream (Jul).
Status unknown.

Class COPEPODA

Order EUCOPEPODA

There are many cyclopoid copepods inhabiting caves and grounwaters worldwide. Together with ostracods and microdrile oligochaetes they are the dominant invertebrates of cave waters in Nova Scotia, and certainly include troglophilic species.

Family Cyclopoidae

ACANTHOCYCLOPS ROBUSTUS

CB, one copepodid, d.z. in pool with plant flood debris (Jun); one female, d.z. hyporheic (Sep).

Troglophile (?). A widely distributed cosmopolitan species.

ACANTHOCYCLOPS BREVISPINOSUS

WB, one copepodid stage V male, d.th. in stream (Jul).

Troglophile (?). A widely distributed species.

ACANTHOCYCLOPS VENUSTOIDES Coker (cf A. PILOSUS Kiefer)

PT, abundant, th. Sediment rich organic (porcupine dung) (Apr).

Accidental Trogloxene (?). A rather rare nearctic species. *A. pilosus* is treated by most authors as a synonym of *venustoides*: the specimens from PT agree with *pilosus* (Reid, pers. comm.). They were collected just inside the entrance of the adit, and are unlikely to be cavernicolous.

EUCYCLOPS AGILIS Koch

CB, one male and one female, d.z. in pool with plant flood debris (Jun).

Troglophile. A very common, cosmopolitan copepod. Often found in caves both in North America and Europe, and is considered to be a troglophile.

DIACYCLOPS CRASSICAUDIS var. BRACHYCERUS

WB, one female, d.th. in stream (Jul): WIC, common (eight females collected), d.th. in small stream with porcupine dung (Sep).

Troglophile (?). A widely distributed species.

PARACYCLOPS POPPEI

CB, two females, d.z. in pool with plant flood debris (Jun).

Accidental Trogloxene (?). Widely distributed species.

MACROCYCLOPS ALBIDUS

CB, one female, d.z. hyporheic (Sep).

Troglophile (?). Widely distributed species.

Class MALACOSTRACA

Order ISOPODA

Isopods - both terrestrial and aquatic - are one of the most typical invertebrates of caves, Hundreds of cavernicolous species are known worldwide. They are however very poorly represented in Nova Scotia caves where only one woodlouse species (a common European introduction) has been found. This reflects the paucity of the isopod fauna north of the limits of the Pleistocene glaciations.

Family Oniscidae

ONISCUS ASELLUS (Linnaeus)

FC, common, d.th. on walls (Oct); one, d.z. on porcupine dung (Jun): F2, one, d.z. under

stone in area covered by porcupine dung (Jun); one, d.z. on wall (Oct); two, d.z. on wall (May); several, d.th. on rock surfaces (May): WB, one, th. on wall (Jul).

Regular Trogloxene. Habitual inhabitant of damp cave entrances, occasionally encountered further in. A European introduction, now very common and widespread in epigean habitats.

Class **CHILOPODA**

Although a number of cavernicolous species are known worldwide, centipedes are infrequent in caves in northern regions of Europe and America.

Order LITHOBIOMORPHA

Family **Henicopidae**

LAMYCTES FULVICORNIS Meinert

FC. one, d.th. (Jun).

Accidental Trogloxene. A European introduction, now widespread in North America. It is unusual in caves.

Class **DIPLOPODA**

Millipedes are common in caves and there are numerous troglobitic species elswhere in the world. None of the Nearctic millipedes recorded from epigean habitats in Eastern Canada have been found in our caves; the four species listed below are all introduced Palaearctic forms. However, all are quite common in caves in Europe, so it is not surprising that they have also been able to establish themselves in the same habitat here.

Family **Blaniulidae**

PROTEROIULUS FUSCUS (Am Stein)

FC (Calder & Bleakney, 1967); one,d.th. pitfall (Jul); one, th. Tullgren sample (Jun); one, th. pitfall (Aug) (Calder collection records); one, th. from 'soil' (Oct) (Calder, pers.comm.).

Regular Trogloxene (?). An introduced Palaearctic species, common in caves in Europe. It appears to have been common in Frenchman's Cave in 1964 (a specimen was also taken outside the cave in the sinkhole) but has not been found there since then.

Family **Iulidae**

OPHYIULUS PILOSUS (Newport)

FC (Calder & Bleakney, 1967); one, d.th. pitfall trap (Jul) (Calder, pers.comm.); one, d.z. in porcupine dung (Jul); one, d.z. on porcupine dung (Oct): F2, two, d.z. in porcupine dung (Jul).

Troglophile (?). Introduced Palaearctic species. Common in caves in Europe. Several records over a period of three decades from the Frenchman's Cave system suggest that it may be established there.

CYLINDROIULUS LATESTRIATUS (Curtis)

FC (Calder & Bleakney, 1967, as *Diploiulus)*; one, d.th. pitfall trap (Jul); one, th. Tullgren sample (Jun); one, th. pitfall trap (Aug) (Calder collection records); one, d.z.under stone (Jun): F2, one, d.th on clean damp pebble (Oct).

Troglophile (?). An introduced Palaearctic species, often found in caves in Europe. The number of records suggests that it is established in the Frenchman's Cave system.

Family **Polydesmidae**

POLYDESMUS ANGUSTUS (Latzel)

FC, common, th. under stones and in porcupine dung (Oct); one, d.th. on wall (Oct).

Troglophile (?). An introduced European species, common in caves there. In Nova Scotia it has only been taken in one cave, where it is frequent in decomposing porcupine dung in the threshold. It was not found by Calder & Bleakney, suggesting that it has only recently become established there.

Class **SYMPHYLA**

Many Symphyla feed on plant roots, and so are excluded from typical cave habitats. However there are some species that live on decaying wood and other plant debris, and these can be cavernicoles.

Family **Scolopendrellidae**

SYMPHYLELLA sp. indet.

MB, two, d.z. under stones (Aug).

Troglophile (?). Some species of this genus are troglophilic elswhere, but more records are needed to confirm the status of this form in Nova Scotia.

Class **INSECTA**

Order COLLEMBOLA

Collembola are one of the most important components of cave faunas everywhere. There are many troglobitic species. Although no troglobites have been found in Eastern Canadian caves, there are a number of good troglophiles: those frequently found in Nova Scotia include Folsomia candida, Heteromurus nitidus and Arrhopalites hirtus.

Family **Poduridae**

HYPOGASTRURA (CERATOPHYSELLA) PSEUDARMATA (Folsom)

No Nova Scotia cave records.

Accidental Trogloxene (?). Widespread but uncommon North American species.

NEW BRUNSWICK. KC, several, d.z., on damp timber (Oct).

NEANURA MUSCORUM (Templeton)

No Nova Scotia cave records.

Troglophile. An introduced European species, often found in caves. Peck (1988) found it in one mine in Ontario. I have frequently found it in epigean habitats in Nova Scotia, and it may be expected in caves here.

NEW BRUNSWICK. KC, common, d.z., on damp timber. (Oct).

WILLEMIA SCANDINAVICA Stach

WIC, several, d.th. in porcupine dung (Jul), several, th. in plant debris (Jul).

Regular Trogloxene (?). A rare species with a somewhat northerly distribution. Most records are from Europe: the only prior North American record is from Alaska. Its occurrence at this site suggests that WIC supports a northern faunal element.

Family Onychiuridae

ONYCHIURUS (PROTAPHORA) PSEUDARMATUS (Folsom)

FC, abundant, d.z. in porcupine dung (Jul): HC, one, d.z. on wet timber (Mar): WIC, d.th. in porcupine dung (Jul).

Troglophile or Guanophile. Distribution: North America and Greenland. It appears to be common in Nova Scotia caves.

ONYCHIURUS ARMATUS (Tullberg) species complex

FC, (Calder & Bleakney, 1967, Christiansen & Bellinger 1980 p. 412): HC, common, d.z. in porcupine dung (Aug).

Troglophile (?). Members of this species complex are common in caves.

ONYCHIURUS spp. indet.

Onychiurids, representing several species, are common in porcupine dung, plant debris, on pools, and in other habitats. The collections are being examined by a specialist in this Genus.

TULLBERGIA IOWENSIS Mills

FC, (Calder & Bleakney, 1967, Christiansen & Bellinger 1980 p. 412).

Troglophile (?). Widespread but uncommon North American species.

TULLBERGIA ROSEKI Christiansen and Bellinger

HC, common, d.z. in porcupine dung (Aug).

Guanophile (?). A rare species about which little is known. Christiansen and Bellinger (1980) list only one locality, the type locality (Indiana).

TULLBERGIA COLLIS Bacon

FC (Calder collection records).

This species is listed without details in a set of identifications of Frenchman's Cave collembola collected by Calder. It was apparently not however found amongst specimens sent to Dr. Christiansen, and I am inclined to think it a misidentification. *T. collis* is a widespread North American species.

Family Isotomidae

FOLSOMIA FIMITARIA (Linnaeus)

FC, the commonest isotomid found by Calder and Bleakney (1967). Also see Christiansen & Bellinger 1980 p. 641.

Troglophile. A common European species. Most of the North American records are unreliable because the species has been confused with *F. stella* and, sometimes, *F. candida.* The above Nova Scotia cave record is the only confirmed occurrence of the species in North America (Christiansen & Bellinger 1980 p. 641). In view of this, it is possible that some or all of the records reported below as *stella* are actually of *fimetaria.*

FOLSOMIA STELLA Christiansen & Tucker

FC, abundant, d.z. in decomposed porcupine dung (Jun); occasional d.z. in porcupine dung (Jul): HC, occasional, d.z. on damp wood (Mar): WIC, one immature specimen, d.th., in porcupine dung (Jul); several, th. in plant debris (Jul)

Troglophile. Nearctic. The species here reported as *Folsomia stella* is the most common isotomid in Nova Scotia caves, often being abundant in organic material, especially porcupine dung. However this species is difficult to separate from *F. fimitaria* and, in view of the earlier confirmed presence of the latter in FC, it is possible that some or all of the recent Provincial cave records are of *fimitaria.*

FOLSOMIA CANDIDA (Willem)

MIC, abundant, d.th. in decomposed porcupine dung (Sep); well (covered), on water surface, abundant, Chester, Lunenberg County (Mar); well (covered), on water surface, abundant, Weymouth, Digby County (Jan).

Troglophile. Nearctic, southern Canada and the whole of the United States. Widespread but sporadic. Often found in wells as well as caves, sometimes in large numbers (it is frequently parthenogenic). The extant Nova Scotia records suggest that its distribution in this province follows a similar pattern. Although *Folsomia candida* is often confused with *F. fimitaria* the present records were confirmed by Dr. K. Christiansen (Grinnell College, Iowa) and may be considered reliable.

ISOTOMA (DESORIA) NOTABILIS Schäffer

FC, common (Calder and Bleakney 1967).

This is a common, widespread species in North America, and is often found in caves. It has not however been found in any local cave since the early record above. In view of the fact that *Isotoma notabilis* is a relatively large and conspicuous species that is not likely to have been overlooked, I am inclined to believe that this record actually represents the following, probably undescribed, *Desoria.*

ISOTOMA (DESORIA) sp. nova?

F2. Common, d.th. on plant flood debris and also taken in pitfalls nearby (Oct); occasional d.z. in porcupine dung (Oct): HC, d.th.-d.z.on wet timber (Mar)and pools (Aug).

Troglophile (?). This is either an undescribed species, or may be a European introduction: it has certainly not been recorded before in North America. The number of Nova Scotia cave records suggests that it may be a troglophile. It appears to be fairly common in caves in Hants County.

ISOTOMA (DESORIA) CAERULEATRA Guthrie

CB, one, d.z., in plant flood debris.

Accidental Trogloxene. A rare North American species, not known to be cavernicolous: this single record, from flood debris, is thus almost certainly of an accidental.

Family Entomobryidae

HETEROMURUS NITIDUS (Templeton)

FC, one specimen, th. (Calder & Bleakney, 1967: Christiansen & Bellinger 1980 p. 1000): MB, several, d.z. under stones (Aug). There is a thriving colony in F2, where it is found d.th.-d.z.under stones, on pools, and amongst vegetable debris.

Troglophile. This species is probably introduced in North America (Christiansen & Bellinger 1980). Common in caves both here and in Europe. All of the Nova Scotia and New Brunswick cave records are from sites with streams and clean mud-free conditions.

NEW BRUNSWICK: KC, several, d.z. on wet timber (Oct).

PSEUDOSINELLA ALBA (Packard)

FC, thirty-one specimens, th.(Calder & Bleakney, 1967; Christiansen & Bellinger 1980 p. 968): HC, d.z., on pool (Nov).

Troglophile. It is interesting that whilst Calder & Bleakney found this species to be the most common entomobryid in FC, it has only turned up once subsequently in Nova Scotia cave collections. According to Christiansen & Bellinger (1980) European " *alba* " may be a distinct species.

PSEUDOSINELLA COLLINA Wray

No Nova Scotia records.

Troglophile. Widely distributed in the USA and Canada.

NEW BRUNSWICK: KC, one specimen tentatively assigned to this species, d.z. on wet timber (Oct).

ENTOMOBRYA NIVALIS (Linnaeus).

FC, one, th.(Calder & Bleakney, 1967).

Accidental Trogloxene. *E. nivalis* is a common widespread epigean species, but is unusual in caves. Peck (1988) reported it from a cave in Ontario. The single Nova Scotia cave record is almost certainly a stray: the species is common in the sinkhole outside the cave entrance.

TOMOCEROS MINOR (Lubbock).

CB, one specimen, d.z., on porcupine droppings (Jun).

Troglophile (?). A European introduction, collected at various sites on the East coast of North America, from Nova Scotia to New York: most records are from port cities or from greenhouses (Christiansen & Bellinger 1980). I have found it to be common in many parts of Nova Scotia. It is a frequent and widespread troglophile in Europe so this Nova Scotia cave record may indicate that it is starting to become established in our caves.

Family Neeliidae

MEGALOTHORAX MINIMUS Willem

FC, (Calder and Bleakney 1967, Christiansen & Bellinger 1980 p. 1048.)

Regular Trogloxene (?). A widespread North American species, usually overlooked due to its small size.

Family Sminthuridae

ARRHOPALITES PYGMAEUS (Wankel)

FC, one, d.th.(Calder and Bleakney 1967, Christiansen & Bellinger 1980 p. 1110.)

A doubtful record considering that it was based in a single specimen and the species has not been found again in any local cave. It may have been the same species as the following.

ARRHOPALITES sp. near PYGMAEUS

F2, d.th. on plant debris near the stream (Oct).

Differs from typical *pygmaeus* and may be an undescribed species (Christiansen, pers. comm.).

ARRHOPALITES HIRTUS Christiansen

F2, d.th.-d.z., on pools and under stones near stream, common (Oct).

Troglophile. There appears to be an established colony in this cave. A North American species, widespread but sporadic.

PTENOTHRIX MARMORATA (Packard).

FC, one, th. (Calder & Bleakney, 1967; Christiansen & Bellinger 1980 p. 1223): CB, immature *Ptenothrix* probably this species, d.z. on pool (Jun).

Regular Trogloxene. Widespread and common North American species.

NEW BRUNSWICK. KC, common, d.z., on wet timber in stream passage. (Oct) (Atypical specimens).

Order EPHEMEROPTERA

No Ephemeroptera have so far been collected in Nova Scotia caves. However McAlpine (1977) found "Ephemeroptera" in caves in New Brunswick (no details) and Peck (1988) lists four species from Ontario, so they may turn up in suitable caves here.

Order ODONATA

Occasional dragonfly nymphs are seen in cave thresholds in both ponds and streams (but only those which have a direct connection with surface waters). They are undoubtedly major predators in these habitats.

Family Aeshnidae

AESHNA UMBROSA Walker

HC, one medium instar nymph, probably this species, d.th., in pond (Oct).

Regular Trogloxene. *A. umbrosa* is a common lacustrine and riverine species in Nova Scotia. It is a crepuscular species which is expected in this habitat (Brunelle, pers. comm.).

AESHNA sp(p). indet.

HC, nymphs of two species in first pond (th.-d.th.) (Jul). Reported by Wright (1985), but no voucher specimens were collected (Scott 1979) and the record can not be confirmed. It is likely that *A. umbrosa* was represented.

Regular Trogloxene (?). Peck (1988) reported a nymph of this genus from a cave in Ontario.

Family Cordulegastridae

CORDULEGASTER MACULATUS Selys.

CB, one nymphal molt, d.th., on muddy stream bed (Sep).

Accidental Trogloxene (?). A molt "could have been carried for some distance in any reasonable flow of water, possibly miles" (Brunelle, pers. comm.). The stream flows into this cave through scree so it is unlikely, but certainly not impossible, that the specimen was carried in, and this record has to be treated as doubtful.

Family Macromiidae

MACROMIA ILLINOIENSIS Walsh

HC, nymphs, in pond (th.-d.th.) (Jul).

Reported by Wright (1985), but no voucher specimens were collected (Scott 1979) so this record cannot be confirmed: I have never seen these short-bodied nymphs in any cave in Nova Scotia.

Order PLECOPTERA

Plecoptera nymphs are sometimes found in near-surface cave streams but are never more than Regular Trogloxenes. Those that have been found in Nova Scotia caves require clear cold streams, and do not occur in the more usual mud bottomed cave streams.

Family Chloroperlidae

?SWELTZA sp. indet.

F2, nymphs abundant, d.th.-d.z. amongst stream gravel (May-Jun); imagos (just emerged), d.th. on damp rocks (Jun).

Regular Trogloxene. Nymphs are always present in this cave in the Spring season.

Chloroperlid sp(p) indet.

FC, nymphs occasional, th.-d.th. in stream (Oct): WB, one nymph, d.th. in stream (Jul).

Accidental Trogloxene (?).

Order ORTHOPTERA

Many species of Camel Crickets of the Genus Ceuthophilus are found in caves in the United States, but, with the exception of one species, they seem not to extend into caves in Canada. This species (C. brevipes) has been found in only two underground sites in Nova Scotia (one of which has since been quarried away), and appears to be at or near its northern range limit here.

Family **Rhaphidophorinae**

CEUTHOPHILUS BREVIPES Scudder

TH, two, d.th. on wall (Oct), several, d.th. on wall (Sept): PT, several, d.th. on walls (Oct), several adult males, females and imm., th.-d.th on walls (Apr).

Regular Trogloxene. Common in caves in Eastern North America. Peck (1988) found it in several Ontario caves. It has been rarely seen in caves in Nova Scotia, though the population in PT appears to be established. It may be near the limit of its geographical range here.

Order COLEOPTERA

Worldwide, the beetles are the most successful and diverse group of cavernicolous insects. At least twenty-two families contain cavernicoles. The greatest diversity and cave specialization is found in the Trechidae and the Leiodidae. The Staphylinidae also contain a number of cavernicoles in Europe and North America.

Family **Dytiscidae**

AGABUS SEMIVITTATUS (Le Conte)

CB, one adult, d.z. in stream with plant flood debris (Jun).

Accidental Trogloxene. Widespread epigean species, recorded from NE, SE and SW United States (Downie & Arnett 1996) and, in Canada, Ontario and Quebec (Bousquet, 1991).

AGABUS LARSONI Ferry and Nilsson

HC, one adult, d.z. in pond (Aug).

Accidental Trogloxene. A common species, usually found in *Sphagnum* bogs.

? DYTISCUS sp. indet.

CB, one 3rd instar larva, d.z. in stream (Jun).

Accidental Trogloxene.

Family **Leiodidae**

? TRIARTHON sp. indet.

F2, one, th. on wall (Oct).

Accidental Trogloxene.

Family **Staphylinidae**

QUEDIUS MESOMELINUS (Marsham)

No Nova Scotia cave records.

Troglophile. A Palaearctic species, probably introduced in North America and now widely distributed (Smetana 1971). It is found in caves on both continents. Peck (1988) reported it from a mine adit in Ontario. Synanthropic: cellars and similar places; burrows, tree-holes, etc. (Smetana *op. cit.*)

NEW BRUNSWICK. KC, one adult, d.z. on plant debris (Oct).

Breeding. KC, larva probably this species by virtue of adult occurrence, d.z. on plant debris (Oct).

QUEDIUS SPELAEUS Horn

FC (Calder & Bleakney, 1967), three adults, d.z. under stones (Jun): F2, two adults, d.z. under stones in area covered by porcupine dung (May): FH2, one adult, d.z. in deposit of fish bones (Oct)

Troglophile. Widespread though uncommon North American species, usually found in caves, but also sometimes in habitats such as ants' nests.

Breeding. Larvae: FC, several, d.z. under stones (Jun); two, th. in porcupine dung (Oct): F2, two dead, d.z. in stream (May); one, d.th. under stone in area covered by porcupine dung (Jun); common d.z. under stones, in porcupine dung, and one (dead) in stream (Oct): WIC, one, d.z. under rock near porcupine dung (Oct). Emergent adults: F2, one, d.z. under stone (Oct). Adults reared in laboratory (Oct - Nov) from larvae collected in F2.

BRATHINUS NITIDUS Le Conte

FC (Calder & Bleakney, 1967): FH2, one adult, d.z. in deposit of fish bones (Oct).

Troglophile. An introduced European species, now widely distributed in Eastern North America. Often met with in caves on both Continents.

Family Aleocharinae

? XENOTA (= ATHETA) sp. indet.

PT, one dead adult, d.th. on roof (Aug).

Accidental Trogloxene.

Family Scarabaeidae (Aphodiinae)

APHODIUS ALEUTUS Eschschultz.

FC (Calder & Bleakney, 1967 as *A. leopardus* Horn, 1870), the record was based on one adult, d.th. on porcupine dung (Oct) (Calder collection records).

Guanophile.

Breeding. FC, six larvae, probably this species by virtue of adult occurence, d.th. from porcupine dung (Sept and Oct).

Family Lathridiidae

CORTICARIA ?PUBESCENS Gryllenhal

MIC, one female, d.th. in porcupine dung (Sep).

Accidental Trogloxene or Guanophile.

Family Ptilidae

? ACROTRICHIS sp. indet.

F2, abundant, d.th.-d.z. in porcupine dung (Oct).

Guanophile. May be a troglophile: although it has yet only been found in one cave here, it is abundant there and the presence of larvae and pupae indicates that it is able to complete its life cycle underground. This appears to be an established population.

Breeding. F2, larvae and pupae, assumed this species by virtue of adult occurrence, d.th.-d.z. in porcupine dung (Oct),

Ptilid sp. indet.

HC, one adult, d.z. from porcupine dung (Aug).

Guanophile.

Order TRICHOPTERA

No Trichoptera have so far been collected in Nova Scotia caves. However McAlpine (1977) found "Trichoptera" in caves in New Brunswick (no details) and Peck (1988) lists nine species, representing six different Families, in Ontario, so they are likely to be present in suitable caves here.

Order LEPIDOPTERA

SCOLIOPTERIX LIBATRIX (Noctuiidae) and TRIPHOSA spp. (Geometridae) adults are c inhabitants (Regular Trogloxenes) of caves and mines in Europe and North America. The Family Tineidae includes a number of cavernicolous (guanophile) species in the tropics, so some Canadian members of the group may have the potential to survive in suitable cave habitats, such as porcupine dung. The single record reported here however is probably merely an accidental.

Family Tineidae

AMYDRIA EFFRENTELLA Clem

PT, one adult, th., on wall (Aug).

Accidental Trogloxene (?). A common species, but not usually associated with caves. The caterpillars feed on organic matter, so it is possible that this individual was from porcupine dung or other organic material in the tunnel threshold. *Amydria arizonella* Dietz caterpillars are found on animal dung in American caves.

Family Geometridae

TRIPHOSA HAESITATA AFFIRMARIA (Walker)

No Nova Scotia cave records.

Trogloxene: Parietal Association. Nearctic. Common in caves in Ontario and Quebec: Peck (1988) records it from six caves and mines in Ontario. The species is present in Nova Scotia and, though reported as "rare" by Ferguson (1955), thus may occur here in suitable caves and mines.

Family Noctuiidae

SCOLIOPTERIX LIBATRIX Linnaeus

HC, one, d.th., on wall (Mar) (Anon 1974): FC, one, th., on wall (Oct): PT, one, d.th., on wall (Oct). Sight records from several other sites.

Trogloxene: Parietal Association. Northern circumpolar distribution; adults common in caves in Europe and North America throughout most of the year. Peck (1988) records it from six Ontario caves and mines. In Nova Scotia, Ferguson (1955) reported it as widespread. In caves here it is widespread but nowhere common.

NEW BRUNSWICK. GR; GB; and GM (McAlpine, pers. comm.): HO, four seen, th.-d.z (Mar) (Anon 1976): "is often seen in New Brunswick caves and mines" (McAlpine 1977).

Order DIPTERA

The Diptera are one of the most important components of cave faunas, especially in cool temperate regions . For example Leruth (1933) found 127 species in Belgian caves, Jeffersen (1981) reported 120 species from the British Isles, and Peck (1988) 143 species from Ontario. Many of these are rare or occasional, and a much fewer number of species can be considered to form the normal fauna in the caves.

Most Nova Scotian cave flies are members of the Parietal Association. There is also a group of species that are primarily guanophiles, the larvae being found living in porcupine dung.

Sub-order NEMATOCERA

Family Sciaridae

BRADYSIA sp(p). indet.
FC (Calder & Bleakney, 1967) (three species were collected according to collection records).

LYCORIELLA sp(p). indet.
FC d.z. in porcupine dung (Jul)(Calder collection records): CB, d.z. in porcupine dung (Jun).

SCATOPSCIARA sp(p). indet.
FC , d.z. in porcupine dung (Jul); CB, d.z. in porcupine dung (Jun).

Sciarid sp(p). indet.
FC, one, d.th. on wall (Oct); common. d.z. in molasses trap (Oct); one, d.z. on dung (Oct); common, d.z. on dung and on walls (Jun): F2, abundant, d.th.-d.z. in molasses traps (Oct); one, d.z. on partly decomposed porcupine dung (Oct); one, d.th. attracted to fresh porcupine scat (Oct): CC, abundant, d.z. in molasses trap (Nov); occassional, d.z. on porcupine dung (Oct): PT, one, th. on porcupine dung (Aug).
Breeding. F2, pair *in copula* (Oct); many adults reared from samples of porcupine dung removed to laboratory (Oct).

Family Mycetophilidae

BOLETINA sp. indet.
FC (Calder collection records).
Regular Trogloxene (?). Belonging to the Parietal Association.

BOLITOPHILA sp. indet.
FC (Calder collection records).
Regular Trogloxene. Belonging to the Parietal Association. *Bolitophila* (five species) is common in caves and mines in Ontario (Peck 1988).

EXECHIA sp(p). indet.
HC, one female, d.th. on wall (Mar): MC, one male, (noted as "common th.-d.th"), on rock surface (Oct): PT, one, d.th. on rock surface (Apr): CC, several, d.th-d.z. on rock surface (Nov).
Regular Trogloxene. Belonging to the Parietal Association. *Exechia* (five species) is common in caves and mines in Ontario (see Peck 1988): at least two species are represented in the Nova Scotia cave collections.

EXECHIOPSIS sp. indet.
PT, several, d.th. on roof and walls (Apr): CC, common, d.th.-d.z. on roof and walls (Nov).
Regular Trogloxene. Belonging to the Parietal Association. *Exechiopsis* (seven species) is common in caves and mines in Ontario (see Peck 1988).

TARNANIA TARNANII (Dziedzieki)
PT, several, th.-d.th. on roof and walls (Aug).
Regular Trogloxene. Belonging to the Parietal Association. This species is common in caves and mines in Ontario (see Peck 1988).

Family Culicidae

CULEX sp(p) indet.

MC, females, common, th.-d.th on roof and walls (Oct): CC, several females, d.th. roof and walls (Nov).

Regular Trogloxene. Belonging to the Parietal Association. The females of several species of *Culex* overwinter in caves, basements and similar places. Specific determination of females is difficult (males are necessary in some cases to confirm identifications). Wood et al. (1979) list three species that overwinter in this way and whose known geographical range includes the Maritimes:-

CULEX PIPIENS Linnaeus

Females overwinter in caves, basements and similar places. Known geographical range includes the Maritimes. (Wood *et al.* 1979). This is likely to be the most common species in caves here.

CULEX RESTUANS Theobald

Females overwinter in caves, basements and similar places (Wood *et al.* 1979). This is the only species of *Culex* found in Ontario by Peck (1988). Its geographical range includes the Maritimes (Wood *et al.* 1979), so it is almost certainly present in our caves and mines.

CULEX TERRITANS Walker

Females overwinter in caves, basements and similar places. Its known geographical range includes the Maritimes. (Wood *et al.* 1979), so it is probably present in our caves and mines.

ANOPHELES sp. indet.

WB, one male, th. on wall (Jul).

Regular Trogloxene. A member of the Parietal Association, probably confined to the Threshold. Peck (1988) found three species of *Anopheles* in Ontario caves/mines.

Family Chaoboridae

? CHAOBORUS sp. indet.

F2, one, d.th. near fresh porcupine scat (Oct): WB, a few, th.-d.th., on wall and on plant debris (Jul).

Regular Trogloxene (?). Probably a member of the Parietal Association. Peck (1988) found *Chaoborus albatus* in Ontario (one mine).

Family Chironomidae

SMITTIA sp(p) indet.

FC (Calder & Bleakney, 1967); F2, one female, d.z. on porcupine droppings (Jul).

Guanophile.

Breeding. FC, larvae, d.z. in porcupine droppings (Jul).

Metriocneminid sp. indet..

FC, females common (Sep) (Calder collection records).

An unusual metriocneminid chironomid, possibly representing an undescribed genus. (Calder records).

Family Psychodidae

PSYCHODA sp(p) indet.

F2, one, d.th. on wall (Jun); one, d.z. on wall (Oct).

Regular Trogloxene. A member of the Parietal Association. *Psychoda* (four species) is

common in caves and mines in Ontario (Peck 1988).

Family Tipulidae

LIMONIA CINCTIPES Say

WB, one male, th. on wall (Jul).

Regular Trogloxene. Probably confined to the Threshold Parietal Association. A number of Tipulids are commonly found in this habitat. *L. cinctipes* was found in one cave in Ontario by Peck (1988). It is a widespread epigean species in Nova Scotia.

Family Trichoceridae

TRICHOCERA MACULIPENNIS Meigen

FC (Calder, pers. comm); one, th. on wall (Jun); occassional, d.z. on roof and walls (O common, d.z. in molasses baited trap (Oct): F2, several, d.th. on rock surfaces (Jun); two, d.th. in molasses baited trap (Oct); one, d.z. on wall (Oct): HC, one, d.z. dead on water (Nov): CC, common d.th. on roof and walls (Oct); one, d.z. on wall (Oct); abundant, d.th. in molasses baited trap (Nov)

Troglophile. Holarctic. Very common in Europe where it is frequently found in caves and mines. Peck (1988) found it in four caves/mines in Ontario. Trichocerids have a short pupal stage and the adults are short-lived and do not eat. The larvae live on decaying organic matter and are often coprophagous. There is little doubt that *T. maculipennis* is able to complete its life cycle underground: in Nova Scotia the larvae probably rely mainly on porcupine dung. With the (possible) exception of certain sciarids, it is the most abundant fly in Nova Scotia caves.

Breeding. F2, several adults bred out of porcupine dung collected in F2 (Oct); freshly-emerged adult, d.th. on sandy floor (Oct).

TRICHOCERA sp indet.

WIC, one, d.th. on porcupine dung (Oct)

This species is distinctly larger than *maculipennis* from Nova Scotia caves. It may be *Trichocera hiemalis*, which was found in a mine in Ontario by Peck (1988), and is also known from caves in Europe.

Sub-order BRACHYCERA

Family Phoridae

MEGASELIA (APIOCHAETA) MECONICERA (Specier)

FC (Calder & Bleakney, 1967).

Troglophile (?)

Family Heleomyzidae

SCOLIOCENTRA FRATERNA Loew

FC (Calder & Bleakney, 1967).

Regular Trogloxene: A member of the Parietal Association. Rare. Northerly nearctic and Greenland, the most southerly records being from New York State. Not reported by Peck (1988) from Ontario caves.

HELEOMYZA SERRATA (Linnaeus)

FC, d.th. (Calder, pers. comm): PT, common, d.th., on walls and roof (Aug): CC, occasional, d.th.-d.z. on walls; abundant, d.z. in molasses baited traps (Nov).

Regular Trogloxene: A member of the Parietal Association. Frequent in caves in the Eastern United States, and Peck (1988) found it in three caves/mines in Ontario.

? HELOMYZA BRACHYPTERNA (LOEW)

PT, common, d.th. on roof and walls (Aug).

Regular Trogloxene: A member of the Parietal Association. Widely distributed across

USA, but few previous Canadian records. Has been taken in caves in the USA in winter. Peck (1988) did not find it in caves/mines in Ontario.

? AMOEBALERIA DEFESSA (Osten-Sacken)

CC, ocassional, d.th.-d.z. on roof and walls (Nov): PT, one, d.th. on rock surface (Aug).
Regular Trogloxene. A member of the Parietal Association.

? TEPHROCHLAMYS RUFIVENTRIS (Meigen)

F2, one, d.z., on wall (Oct).
Regular Trogloxene (?). Probably a member of the Parietal Association. Rare in caves in Nova Scotia: it is a large, distinctive species which I have not seen before and only one was present on this occasion.

Family Sphaeoceridae (Borboridae)

LEPTOCERA sp. indet.

FC (Calder & Bleakney, 1967); several, d.z. molasses trap (Oct): F2, one, d.th. on rock surface (Jun), abundant, d.th. in molasses trap (Oct); several, d.th. in small mixed swarm of flies attracted to fresh porcupine scat on a rock (Oct); one, d.z. on wall (Oct); common, d.z. in molasses trap (Oct).
Troglophile. This species is common in Frenchman's Cave and in Frenchman's II. So far, it has not turned up in any other local cave.
Breeding. F2, newly emerged adults, d.z. in molasses trap (Oct).

Order HYMENOPTERA

Rare in caves. Peck (1988) found four species in Ontario. McAlpine (1977) lists "Hymenoptera" from New Brunswick caves, but without further details. However, none were listed by Calder and Bleakney (1965, 1967) and I have not encountered any in Nova Scotia.

Order PSOCOPTERA

There are some cavernicolous Psocoptera, but the single Nova Scotia record is presumed to be of a stray.

Family Liposcelidae

LIPOSCELIS BOSTRYCHOPHILA Badonnel

CC, one *Liposcelis* tentatively identified as this species, d.z., on pool (Oct).
Accidental Trogloxene.

Order HOMOPTERA

Although there are cavernicolous Homoptera elsewhere in the world, there is little evidence that any Canadian species might be cavernicolous. Peck (1988) reported a single Cixiid nymph from one cave in Ontario. Some Aphidae live on plant roots, which may explain the following record, which was from a shallow cave.

Family Aphidae

Aphid sp. indet.

CC, one, d.z., pitfall trap (Nov).
Accidental Trogloxene.

Family Cixiidae

Cixid sp. indet.
FH2, one (nymph), d.z., in deposit of fish bones (Oct).
Accidental Trogloxene.

Class ARACHNIDA

Order ACARINA

The terrestrial mites are important cavernicoles everywhere in the world. In Nova Scotia caves they are the most diverse taxonomic group, and, in many cases also dominate in terms of numbers of individuals. This group certainly includes many significant and notable species here: unfortunately there are no experienced taxonomists willing to work on collections at this time. The following records therefore do not incorporate the large numbers of mites that were collected during the present survey.

Family Acaridae

ACARUS IMMOBILIS Griffiths
"cave", one male and three females , d.z. in porcupine dung (Jun or Jul).
Accidental Trogloxene. A graminivorous species, often a pest of stored grain.

Family Eviphididae

ALLIPHIS sp(p) indet.
FC (Calder & Bleakney, 1967), two females and two males (Oct) (Calder collection records): "cave", three females , d.z. in porcupine dung (Jun or Jul).
Regular Trogloxene (?). *Alliphis* species are predators, often in temporary habitats. Some have also been recorded phoretic on scarabid beetles.

Family Ameroseiidae

EPICRIOPSIS sp. indet.
"cave", two females , d.z. in porcupine dung (Jun or Jul).

Family Parasitidae

PARASITUS sp. nr. LORICATUS (Wankel)
"cave", protonymphs, males and females, d.z. in porcupine dung (Jun or Jul).

PARASITUS sp. nr. NIVEUS (Wankel).
No Nova Scotia cave records.
NEW BRUNSWICK. KC, one male, d.z. on damp timber (Oct).

PARASITUS sp(p) indet.
FC (Calder & Bleakney, 1967), four females and eight deutonymphs (Oct) (Calder collection records): MC, one larva, d.z. damp timber (Oct)

EUGAMASUS sp(p) indet.
FC (Calder & Bleakney, 1967), two males (Oct) (Calder collection records).
NEW BRUNSWICK. KC, female and deutonymphs, d.z. on damp timber (Oct).

VULGAROGASMUS sp. nr. REMBERTI (Oudemans)
"cave", males and females, d.z. in porcupine dung (Jun or Jul).

Family **Pygmephoridae**

PYGMEPHORUS sp. indet.
FC (Calder & Bleakney, 1967), one female (Oct) (Calder collection records).

BAKERDANIA sp. indet.
"cave", one female, d.z. in porcupine dung (Jun or Jul).

Family **Rhagidiidae**

RHAGIDIA WEGERENSIS (Packard)
HC, one, d.z. on damp timber (Mar).
Troglophile (?). *Rhagidia* species are predators. A number of species are cavernicoles.
NEW BRUNSWICK. KC, one female, d.z. in plant debris (Oct).

RHAGIDIA sp. indet.
"cave", two females, d.z. in porcupine dung (Jun or Jul).

Family **Arctacaridae**

ARCTOSEIUS sp. indet.
FC (Calder & Bleakney, 1967), one male (Calder collection records).

Family **Zerconidae**

ZERCONOPSIS sp. indet.
FC (Calder & Bleakney, 1967), one female and one deutonymph (Calder collection records).

Family **Vegaiidae**

VEGAIA KOCKI (Tragardh)
No Nova Scotia cave records.
Troglophile (?). Recorded from one cave in Ontario (Peck 1988). A number of *Vegais* species are cavernicolous.
NEW BRUNSWICK. KC, d.z. in plant debris (Oct).

VEGAIA sp. indet.
FC (Calder & Bleakney, 1967), larvae, protonymphs, deutonymphs and adults (Oct) (Calder collection records).

Family **Macrochelidae**

GEOLAPSIS sp. indet.
FC (Calder & Bleakney, 1967), three females (Oct) (Calder collection records).
Troglophile (?). *Geolaspis* are predatory mites, normally found in forest litter and similar habitats.

Family **Eupodidae**

LINOPODES MOTATORIUS (Linnaeus)

No Nova Scotia cave records.
Troglophile. Widespread species, often found in caves.
NEW BRUNSWICK. KC, several, d.z. from damp timbers (Oct).

COCCEUPODES sp. indet.

MC, one female, d.z. from damp timber (Oct).

Family **Glycyphagidae**

GLYCYPHAGUS DOMESTICUS (De Geer)

MC, larvae, protonymphs, males and females, d.z. from damp timber (Oct).
Troglophile (?). This collection suggests a breeding population.

Family **Tetranychidae**

BRYOBIA PRAETIOSA (Koch)

FC (Calder & Bleakney, 1967), six females (Oct) (Calder collection records).
Accidental Trogloxene. An epigean form (probably a species complex) found on vascular plants. Parthenogenic.

Order ARANEIDA

Spiders are important predators in cave communities worldwide, and include many troglobitic species. There are also many species of spider that are adapted to exploiting the threshold zone. In tropical regions there are dozens of species representing several families that do this, but the diversity of this specialised fauna decreases in temperate regions, and in Nova Scotia only one true Threshold Parietal species has been found - the Cave Spider Meta ovalis. Another widespread Threshold Parietal spider, Nesticus pallidus, has not turned up in Nova Scotia caves, although I expected to find it. It occurs in Ontario (Peck, 1988).

Family **Araneidae**

ARANEUS CAVATICUS (Keyserling)

No cave records in Nova Scotia.
This species occurs in the United States and southern Canada under bridges and overhanging cliffs, and there is a cave record from Alabama (Levi 1971). It has been found occasionally in epigean habitats in both Nova Scotia and in New Brunswick and may possibly turn up in cave or mine entrances here if searched for.

Family **Metidae**

META OVALIS (Gertsch)

FC (Calder & Bleakney, 1967), one female (Feb)(NSMNH Coll.): F2, one female, d.th. on wall (Oct); one female, th. on roof (Jun); one male, th. on web (Oct); several males, on walls (Oct): WB, several, d.th. on webs and rock surfaces (Jul): HC, one female, d.th. on wall (Mar): PT, two females, th. on wall (Apr); one male d.th. on wall (Apr); one male (Oct): CB, one male (Nov) (NSMNH Coll); one female, d.th. (Nov) (NSMNH Coll): FH2, one female, d.th. on wall (Oct): crawlspace under cottage, one female, Halifax County (Sep)(NSMNH Coll); one male (Sep) (NSMNH Coll): "among stones in damp woods and more often in cellars, wells and drains" (Emerton, 1917): a few individuals under "a well-cover at South Harbour", Victoria County (Lafontain *et al.* 1987).

Troglophile. A major predator of Threshold Parietal Association. Common in caves, mines, cellars and similar places throughout Eastern North America (mainly east of the

Mississippi River). The early records were erroneously reported as the Palaearctic species *Meta menardii*. Separation of the two species (Marusik and Kaponen 1992) was based on Canadian material collected in Nova Scotia, New Brunswick, Quebec and Ontario. Type specimens from these localities are preserved in the Canadian National Collection and in the Zoological Museum, University of Turku).

NEW BRUNSWICK. HO,HB,GR,GB,GM, KC (McAlpine, pers. comm.)

Breeding. Under back step of house, Halifax County, adult female and egg case (Oct) (NSMNH Coll); In crawlspace under cottage, Halifax County, gravid female (Sep) (NS Coll); FC, several juveniles, th. on wall (Oct); WB, juveniles, common, th. on wall (Jul); CB, one juvenile, d.th (Nov).

Family **Agelenidae**

CIRCURINA BREVIS (Emerton)

WIC, three males, th. in pitfall trap set amongst scree inside entrance (Oct/Nov).

Accidental Trogloxene (?). Based on specimens in the NSMNH collections, this spider appears to be fairly common and widespread in epigean habitats in Nova Scotia. It is not usually considered a cave spider, but was also recorded by Peck (1988) from one cave in Ontario, so may in fact be more common than previously suspected in cave entrances. It is not however a Parietal species, and will be found instead amongst plant litter, scree and similar habitats.

Family **Erigonidae**

SISICOTTUS MONTANUS (Emerton)

FC, one female, d.z. in porcupine dung (Jul).

GRAMMONOTA sp. indet.

CB, one juvenile (second specimen, likely the same species, nearby), d.z. on porcupine dung (Jun).

Order OPILIONES

Harvestmen are important cavernicoles in many parts of the world and include many troglobites. There are also several species that use caves for overwintering, including one, Leiobunum elegans, in the Maritimes.

Family **Phalangiidae**

OLIGOLOPHUS TRIDENS (C. L. Koch)

CC, one, d.z. in pitfall trap (Nov): WIC, one, th. in pitfall trap set under scree inside entrance (Oct/Nov).

Accidental Trogloxene. A palaearctic species, introduced in North America (Bell, 1974). In Europe it is common and widespread, but only rarely collected in caves. For example Leruth (1939) records it from two caves in Belgium, but is not on Turk's (1967) list of the British cave harvestmen.

LEIOBUNUM ELEGANS Weed

F2, one, d.th. on wall (Oct) (sight record); PT, several hundred adult males and females, many forming aggregations, observed overwintering (Oct-May). (Moseley and Hebda, in prep.). HC, one juv., d.th. on wall (Mar), one juv., d.z. on boulder (May); FH2, juveniles common, d.th.-d.z. on walls (Oct); MC, several juveniles, d.th. on walls (Oct); CC, d.z., one, in pitfall trap (Oct).

Regular Trogloxene. A nearctic species, widely distributed and generally common throughout Eastern North America. Overwinters in caves, mines and similar situations.

NEW BRUNSWICK. KC, two juveniles, d.th. on wall (Oct). "Opilionids noted in many New Brunswick caves are all probably (this species)" McAlpine (1977).

Class GASTEROPODA

Order PULMONATA

Several species of slugs and snails may be found in damp, sheltered cave thresholds; occasionally further in. Some are Accidentals, but some species are members of the Threshold Parietal Association and thus may be considered bonafide cavernicoles here.

Family Arionidae

ARION FASCIATUS (Nilsson)

FC, two, th. on walls (Oct): PT, one, th. on wall (Aug).

Regular Trogloxene. Member of the Parietal Association and probably confined to the Threshold. A European species, introduced in North America. Common in surface habitats. Peck (1988) reports it from one cave in Ontario.

Family Limacidae

DEROCERAS LAEVE (Müller)

F2, d.th., one, on wall (Jun).

Regular Trogloxene (?), probably confined to the Threshold Parietal Association. A common holarctic species, found throughout Nova Scotia. Davis (1985) found it common in Hayes Cave Provincial Park. Peck (1988) reports it from one cave in Ontario.

Family Helicidae

TRICHIA HISPIDA (Linnaeus)

F2, th. one, on wall (Oct).

Accidental Trogloxene (?). A European species, introduced in North America. Widespread and locally common in Nova Scotia..

Family Zonitidae

ZONITOIDES ARBOREUS (Say)

FC, d.th., one, on wall (Oct): F2, several, th.-d.z. on walls (Jun).

Regular Trogloxene. A member of the Parietal Association which appears at home in the Dark Zone as well as the Threshold. A common native species, found throughout Nova Scotia. Peck (1988) reports it from two caves in Ontario.

Family Endodontidae

DISCUS CATSKILLENSIS Pilsbry

No Nova Scotia cave records.

Troglophile (?). A widespread North American species. It has been taken in caves both in New Brunswick and in Ontario (Peck [1988] reports it from five Ontario caves) and it is locally common in surface habitats here. Davis (1985) found it to be common in Hayes Cave Provincial Park. It may be expected in suitable caves in Nova Scotia., and is well worth search for because it may be a true troglophile.

NEW BRUNSWICK. KC, d.z., on wet timber in stream passage (Sep).

ACKNOWLEDGEMENTS

An investigation of this nature is impossible without the help of many specialist taxonomists, whose contribution is rarely given the prominence that it deserves. I am indebted to numerous individuals who, over the years, have determined specimens from my cave collections in Nova Scotia: Y. Alarie, Canada (Water-beetles); D. Bilton, England (Isopoda); A. Borkent, Canada (Sciaridae); L. Brown, USA (Opilionids); P. Brunelle, Canada (Odonata); J. Campbell, Canada (Coleoptera); K. Christiansen, USA (Collembola); E. Cohn, USA (Orthoptera); D. Danielpol, Austria (Ostracoda); D. Davis, Canada (Gasteropoda); C. Dondale, Canada (arachnids); C. Ewing, Canada (arachnids); K. Hamilton, Canada (Homoptera); S. Hill, Canada (Acari); R. Holmberg, Canada (Opilionida); E. Lindquist, Canada (Acari); P. Marmonier, Austria (Ostracoda); D. Oliver, Canada (Chironomidae); J. Reid, USA (copepods); J. Reynolds, Canada (earthworms); V. Vickery, Canada (Orthoptera); N. Watson, Canada (Plecoptera); B. Wright, Canada (myriapods, Lepidoptera); K. Wu, Canada (Acari).

Thanks are also due to Dr. Dale Calder (Royal Ontario Museum) for making available unpublished records from Frenchman's Cave, and to Calum Ewing (Nova Scotia Museum of Natural History) for unpublished spider records. Calum Ewing and Andrew Hebda (Nova Scotia Museum of Natural History) have both provided a great deal of practical help tracking down references, identifying specimens and in many other ways.

Finally, the cost of field work in 1997 was partially supported by a research grant from the endowment fund of the Nova Scotia Museum Board of Governors.

LITERATURE CITED

ANON 1974. N.S.S.S. Biological Records Part 1. Nova Scotia Speleological Society, Newsletter No. 3. May 1974. pp. 9- 11.

ANON 1975. N.S.S.S. Biological Records, Number 2. Nova Scotia Speleological Society, Newsletter No. 6. November 1975. pp. 8-11.

ANON 1976. Biological Records No. 3. Nova Scotia Speleological Society, Bulletin No. 1. June 1976. pp. 4-5.

BELL, R. T. 1974. A European Harvestman in North America (Phalangida, Phalangiidae). Entomological News 85: 566. p. 154.

BOUSQUET, Y. 1991. Checklist of Beetles of Canada and Alaska. Research Branch, Agriculture Canada, Publication 1861/E.

CALDER, D. R. and J. S. BLEAKNEY 1965. Microarthropod Ecology of a Porcupine-Inhabited Cave in Nova Scotia. Ecology 46: 6. pp. 895-899.

CALDER, D. R. and J. S. BLEAKNEY 1967, Observations on Frenchman's Cave, Nova Scotia, and Its Fauna. Natl Speleol. Soc. Bull. 29: 1. pp. 23-25.

CHRISTIANSEN, K. and P. BELLINGER 1980. The Collembola of North America North of the Rio Grande. Grinnell College, Grinnell, Iowa. 1322 pp.

DAVIS, D. S. 1985. Land and Freshwater Molluscs. In: Morris, L (Ed), 1985, pp. 87-91.

DOWNIE, N. M. and R. H. ARNETT 1996. The Beetles of Northeastern North America. The Sandhill Crane Press, Florida.

EMERTON, J. H. 1917. Spiders Collected in Nova Scotia and New Brunswick by Robt. Matheson in 1912. Proceedings of the Nova Scotia Entomological Society 1917, pp. 95-96.

FERGUSON, D. C. 1955. The Lepidoptera of Nova Scotia. Bulletin No. 2, N.S. Museum of Science, Halifax, Nova Scotia.

GATES, G. E. 1959. Earthworms of North American Caves. Bulletin of the National Speleological Society 21, 2. pp. 77-84.

HOWARTH, F. 1988. Environmental Ecology of North Queensland Caves. In: Pearson, L. (Ed.) Preprints of papers for the 17th biennial conference, Australian Speleological Federation Tropicon Conference, Lake Tinaroo, Far North Queensland, December 27-31, 1988.

JEFFERSON, G. T. 1981. Diptera in British Caves. In: Beck, B. (Ed.) Proceedings of the 8th International Congress on Speleology, Bowling Green, Kentucky. Vol. 1, pp. 106-107.

LAFONTAIN, J.D., S. ALLYSON, V. M. BEHAN-PELLETIER, A. BORKENT, J. M. CAMPBELL, K. G. A. HAMILTON, J. E. H. MARTIN and L. MASNER (Eds) 1987. The Insects, Spiders and Mites of Cape Breton Highlands National Park. Biosystematics Research Centre, Research Branch, Agriculture Canada.

LERUTH, R. 1939. La Biologie du Domaine Souterrain et la Fauna Cavernicole de la Belgique. Memoires du Musee Royal d'Histoire Naturelle, Bruxelles. 506 pp.

LEVI, H. W. 1971. The Diadematus Group of the Orb-Weaver Genus Araneus North of Mexico (Araneae: Araneidae). Bull. Mus. Comp. Zool. 141, 4. pp. 131-179.

MARUSIK, Y. M. and S. KOPONEN 1992. A Review of Meta (Araneae, Tetragnathidae) with Description of Two New Species. J. The Journal of Arachnology, 20. pp. 137-143.

McALPINE, D. F. 1977. Preliminary Investigations on the Ecology of New Brunswick Caves. Unpublished MS.

McALPINE, D. F. and J. W. REYNOLDS 1977. Terrestrial Oligochaeta of Some New Brunswick Caves with Remarks on Their Ecology. The Canadian Field-Naturalist 91. pp. 360-366.

MORRIS, L. (Ed.) 1985. The Hayes Cave Site, South Maitland, Nova Scotia. Curatorial Report Number 50, Nova Scotia Museum, Halifax, Canada. 128 pp.

MOSELEY, M. 1996. The gypsum karsts and caves of the Canadian Maritimes. Cave and Karst Science 23, 1. pp. 5-16.

MOSELEY, M. and A. HEBDA (In prep). Overwintering Leiobunum elegans (Opiliones: Phalangiidae) in Caves and Mines in Nova Scotia.

PECK, S. B. 1988. A review of the cave fauna of Canada, and the composition and ecology of the invertebrate fauna of caves and mines in Ontario. Can. J. Zool. 66. pp. 1197-1213.

SCOTT, F. 1979. Preliminary Investigations at Hayes Cave, Hants County, Nova Scotia in 1978. Curatorial Report Number 38, Nova Scotia Museum, Halifax, Canada. 14 pp.

SCOTT, F. and R. GRANTHAM 1985. The Cave Environment. In Morris, L (Ed), 1985, pp. 101-115.

SMETANA, A. 1971. Revision of the tribe Quedini of America North of Mexico. Mem. Ent. Soc. Can. 79. pp. 1-303.

TURK, F. A. 1967. The Non-Aranean Arachnid Orders and the Myriapods of British Caves and Mines.

Trans. Cave Res. Grp. Great Britain 9, 3. pp. 142-161.

WOOD, D. M., P.T. DANG and R. A. ELLIS 1979. The Insects and Arachnids of Canada. Part 6. The Mosquitoes of Canada. Diptera: Culicidae. Pub. 1686, Canada Dept. of Agriculture, Ottawa. 390 pp.

WRIGHT, B. 1985. Cave Fauna. In Morris, L (Ed), 1985, pp. 123-126.

APPENDIX I: CHECKLIST OF KNOWN NATURAL CAVES* IN NOVA SCOTIA

Existing, confirmed

	Name (County location)	Rock Type	Length
1.	Natural Bridge Cave (Colchester)	Gypsum	10m.
2.	Oxford Lake Cave (Cumberland)	Gypsum	38m.
3.	Cave-of-the-Bats (Halifax)	Gypsum	70m.
4.	Cave D.S. #2 (Halifax)	Gypsum	?
5.	Cave D.S. #3 (Halifax)	Gypsum	?
6.	Cave D.S. #4 (Halifax)	Gypsum	?
7	Cave D.S. #5 (Halifax)	Gypsum	?
8.	Hayes Cave (Hants) (= Five Mile River Cave) (= Maple Grove Cave)	Gypsum	365m.
9.	Un-named Cave (Hants)	Gypsum	15m.
10.	Woodville Ice Cave (Hants) (= Bear Cave, Woodville)	Gypsum	75m.
11.	Frenchman's Cave (Hants)	Gypsum	110m.
12.	Frenchman's II (Hants)	Gypsum	30m.
13.	Weir Brook Cave (Hants)	Gypsum	21m.
14.	St. Croix River Cave (Hants)	Gypsum	15m.
15.	natural cavities, Stevens Mine (Hants)	Limestone	?
16.	Johnson Cove Shore Cave (Hants)	Limestone	4m.
17.	Minasville Ice Cave (Hants)	Gypsum	80m. est.
18.	Cheverie Cave (Hants)	Gypsum	89m
19.	Vault Cave (Kings County) (= Bottomless Pit)	Basalt	25m.
20.	Bailey Brook Cave (Pictou) (= Brown Mountain Cave)	Limestone	? (flooded)
21.	McLellan Brook Cave (Pictou) (= Hermit Cave)	Limestone	85m.
22.	McLeod Cave (Cape Breton)	Limestone	30m.
23.	Point Edward Cave (Cape Breton)	Limestone	293m.
24.	Diogenes Cave (Inverness)	Limestone	171m.
25.	Diogenes II (Inverness)	Limestone	56m.
26.	Munro Brook Cave (Inverness) (= Frizzleton Cave)	Gypsum	154m.
27.	The Ice Hole (Inverness)	Gypsum	5m est.
28.	Mabou Cave (Inverness)	Limestone	15m.
29.	Cave M.1 (Inverness)	Gypsum	10m.
30.	Cave M.2 (Inverness)	Gypsum	20m.
31.	Cave M.3 (Inverness)	Gypsum	6m.
32.	Cave M.4 (Inverness)	Gypsum	5m.
33.	Cave M.5 (Inverness)	Gypsum	88m.
34.	Black River Cave # 1 (Richmond)	Limestone	10m.
35.	Black River Cave # 2 (Richmond)	Limestone	25m.
36.	Big Harbour Cave (Richmond)	Gypsum	30m.

37.	Baddeck Cave (Victoria)	Gypsum	?
38.	Fairy Hole (Victoria)	Limestone	77m.
39.	Fairy Hole II (Victoria)	Limestone	53m.
40.	Fairy Hole III (Victoria)	Limestone	30m.
41.	South Mountain Cave (Victoria)	Calcareous conglomerate	66m.
42.	Cave AY 2 (Victoria)	Limestone	10m.
43.	Cave AY 3 (Victoria)	Limestone	8m.

Quarrried away, but confirmed.

43.	Miller's Creek Cave (Hants) (= Poplar Grove Cave)	Gypsum
44.	The Honeycombs (Hants)	Gypsum
45.	Honeycombs II (Hants)	Gypsum
46.	Little Narrows Cave (Victoria)	Gypsum

Reported, but not confirmed.

--.	Charlie's Fault Cave (Inverness)	?Limestone

Reported in litt., in error

--.	Dalhousie West Cave (Annapolis)	Probably a mine trial.
--.	Peddlar's Cave(Hants) (= Peddlar's Tunnel)	Mine adit, in limestone
--.	Annapolis Valley Cave (Annapolis)	Reported gypsum cave: no gypsum in area.
--.	Miller's Creek Cave Number 2	Part of Miller's Creek Cave.

* with one exception, all are dissolution caves. The exception is Vault Cave (Kings County) which is a tectonic fracture cave in basalt. Seacaves are not listed.